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ESTIMATION OF RUNOFF FOR THE WATERSHED USING SCS-CURVE NUMBER METHOD AND GIS

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ABSTRACT

Runoff is the most important factor considered in watershed management, which depends mainly on the physiographic characteristics of the watershed. In this paper, Estimation of runoff Potential is carried out for Gadela watershed located in Udaipur district, Rajasthan by the most popularly used SCS-Curve number approach, along with GIS. The watershed is delineated and divided into 10 sub basins, using Arc GIS to find the runoff from each sub basin. To calculate the runoff depth, the rainfall of the area from 1994-2014 for 20 years is considered. The thematic maps such as Land use/ Land cover and soil map, were prepared in the Arc GIS environment and overlaid to find the Curve number values. The yearly and basin wise runoff was calculated and presented in the graph. The results found that, runoff depth was more during 2006, which is about 62% of the total average rainfall of 650mm and less runoff in 1998, which is 22%. The average runoff in the watershed basin wise was 115.96mm, of the average rainfall 535.65mm. The sub basin 10 was having the highest runoff, followed by basin 6 and basin 9 and the lowest runoff observed in Sub basin 1 and the Sub basin2. The reason for the runoff from a watershed is, due to the presence of cultivated area about 54.2% of the total area, Scrub land of 44% and forest area only 0.6%.

KEYWORDS: Arc GIS, Rainfall, Runoff, SCS-Curve Number & Thematic Maps

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Original Article

INTRODUCTION

The growth of the global population requires effective utilization of dwindling natural resources, especially for agricultural and livelihood needs. Natural resource development programs are generally applied on a watershed level (Khan, 2001). Watershed is an entity, which helps to dispose the runoff through a single outlet. Runoff is the process which takes place after satisfying the abstraction losses the excess water that goes down without being used for any purpose, due to steep slope and stones in the soil causing soil erosion and converted into degraded land. SCS-CN provides an empirical relationship, for estimating initial abstraction and runoff as a function of soil type and land-use. Curve Number (CN) is an index, developed by the Natural Resource Conservation Service (NRCS), to represent the potential for storm water runoff within a drainage area. (Ashish, 2014).

STUDY AREA

The Gadela Watershed is located in the Udaipur district, which falls under Agro-climatic zone IVA Sub humid region of Rajasthan. The study area is bounded by $73^0$30' to $74^0$15' E Longitude and $24^0$30' to $25^0$0' N Latitude covering Survey of India(SOI) topo sheets of 45H-13,14 and 45L-1, 2 and 9 of 1:50,000 scale. The average rainfall of the study area in monsoon is 535mm, with average number of rainy days 31in a year. The major

soils in the area are Coarse loamy and Loamy Skeltel, which comes under Hydrologic Soil group B.

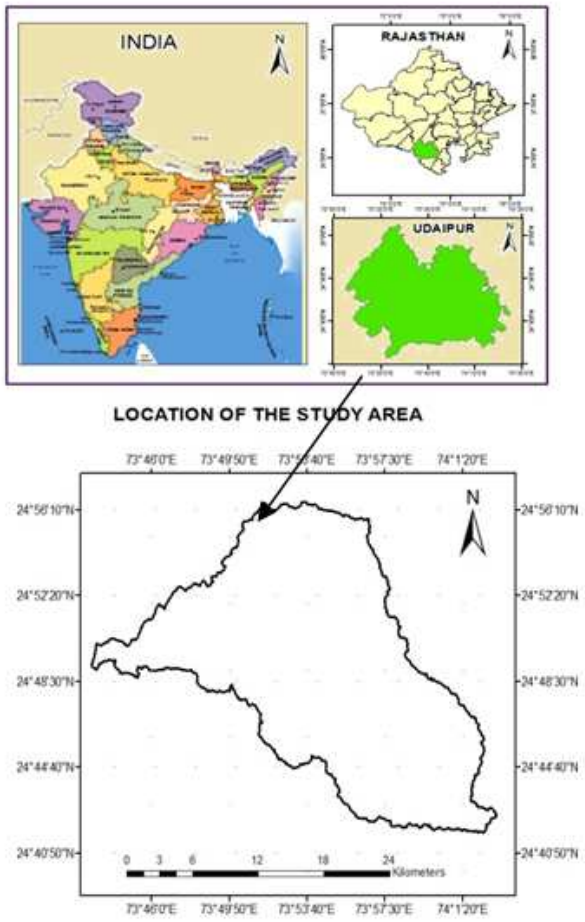

Figure 1: Location of the Gadela Watershed

METHODOLOGY

The rainfall data of the area from 1994-2014, was obtained from Water resource department Rajasthan and the thematic maps Land use/ Land cover image by LISSIII, was downloaded from bhuvan.nrsc.in. The soil map of the study area obtained from NBSSLUP (National Burea of Soil Survey and Land use Planning) was used in Arc GIS, to delineate the soil map of the study area. The watershed was divided into 10 Sub basins and the runoff of the area studied by using SCS-Curve number method. The SCS approach involves the use of simple empirical formulas and readily available tables and curves, developed by the Soil Conservation Service (SCS, 1985). The area consists of cultivated land, Scrub, Barren, Fallow, Forest area and Water bodies, shown in Figure 2. The curve number values are obtained by considering Antecedent rainfall, Land use and Soils of the area. The SCS runoff expressed in unit depth, spread over the watershed for Indian conditions is given by

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S}$$

Where,

Q = Direct flow volume depth, mm

P = total rainfall, mm

S = Potential Maximum soil retention

Curve number value is used to estimate the Potential maximum retention(S)

$$S = \frac{25400}{CN} - 254$$

These table values are applied, only to AMC-II and in order to derive curve number values, for AMC-III the following Correction factors need to be applied (Rao et al., 2010).

CNIII = 1.95 * CNII * exp (-0.00663*CNII)

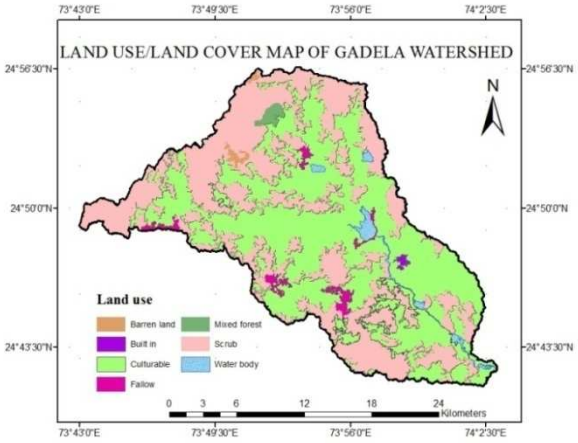

Figure 2: Land Use Map of the Gadela Watershed

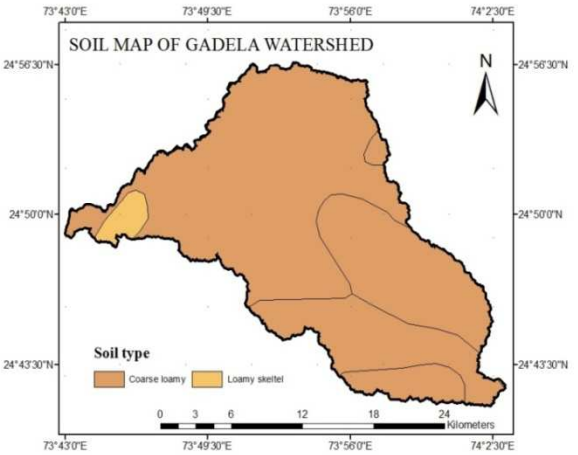

Figure 3: Soil Map of the Gadela Watershed

The curve number values adopted for the study area and AMC conditions, were presented in Table 1 and Table 2.

Table 1: Classification of Antecedent Moisture Conditions (SCS, 1986)

AMC	Dormant Season	Growing Season
I	<12.5	<35
II	12.5 to 27.5	35 to 52.5
III	>27.5	>52.5

Table 2: Curve Number Values for Land Use and Soil Classes

S No.	Land Use	Soil Group	Curve Number
1	Forest	B	63
2	Agriculture	B	78
3	Scrub land	B	67
4	Barren	B	75
5	Fallow land	B	86
6	Built up land	B	85
7	Water body	B	94

RESULTS AND DISCUSSIONS

The monsoon rainfall data from 1995-2014, was collected from the water resource department, Rajasthan and used to find out the runoff from the watershed. The calculated average runoff depth for 20 years was found to be as 184.04mm. The maximum runoff of the watershed was observed during 2006, which was about 62% of the total rainfall and minimum runoff found in 1999 about 18%. The average runoff for the watershed basin wise was 184.39 mm of the average rainfall 535.65mm. The sub basin 10 was having the highest runoff of 195.02mm, followed by basin 6 of 194.83mm and basin 9 with 192.05mm. The lowest runoff has been observed in basin 1 with 172.09mm and the basin 2 having 171.16mm. The variation of direct runoff depth (mm) for basins and Yearly runoff depth were presented in the Figure 4 and Figure 5. The change in land use is considered to be the major factor, in causing surface runoff. Dense vegetation cover facilitates low surface runoff conditions, whereas sparse vegetation and bare surface was having relatively high runoff. It was observed that, Sub basin 10 having the highest runoff due to more percentage area covered in the basin by scrub with sparse vegetative cover and cultivated land. The lowest runoff observed in basin 2 may be due to the presence of forest cover and basin 1 have been covered by Phyllite and schist, which was good in terms of infiltration, which may be the reason for the lowest runoff observed. The calculated runoff values yearly and basin wise were presented in Table 3 and Table 4.

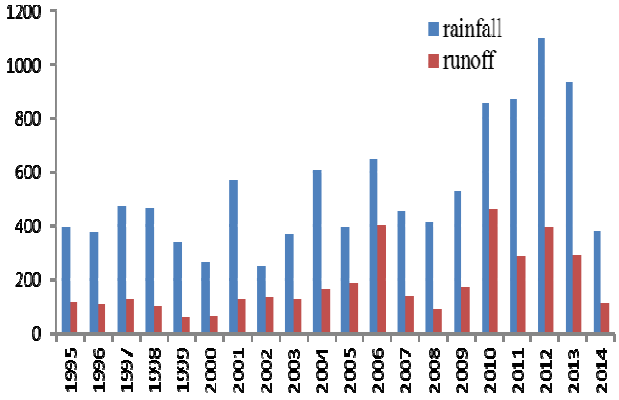

Figure 4: Yearly Runoff Estimated for Gadela Watershed

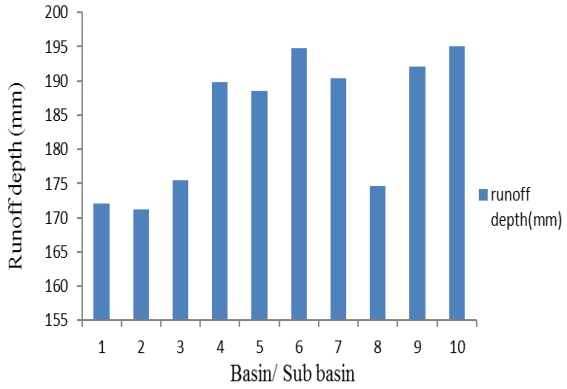

Figure 5: Basin Wise Runoff Estimated for Gadela Watershed

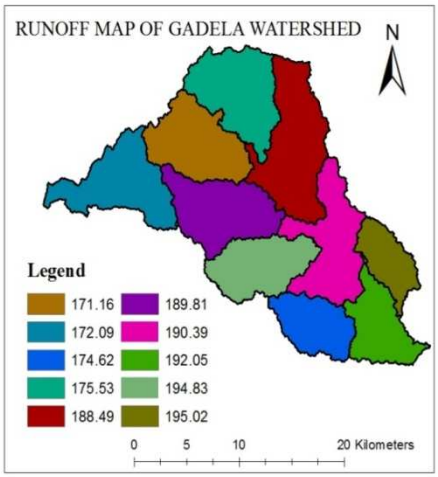

Figure 6: Runoff Map of Gadela Watershed

Table 3: Yearly Runoff Depth (mm) for Gadela Watershed (1995-2014)

S No.	Year	Rainfall, mm	Runoff mm	Runoff %
1	1995	397	117.22	30
2	1996	376	111.36	30
3	1997	467	126.62	27
4	1998	476	100.98	22
5	1999	343	62.29	18
6	2000	266	65.73	25
7	2001	570	128.10	22
8	2002	250	135.39	54
9	2003	369	126.62	34
10	2004	610	166.43	27
11	2005	397	190.80	48
12	2006	650	401.74	62
13	2007	454	137.54	30
14	2008	415	92.78	22
15	2009	530	171.40	32
16	2010	856	463.56	54
17	2011	871	286.02	33
18	2012	1101	395.25	36
19	2013	933	292.8	31
20	2014	382	115.96	30
Average		**535.65**	**184.04**	**33%**

CONCLUSIONS

The yearly runoff depth calculated from 1995-2014 has shown that, of the 535.65 mm average rainfall, 184.04mm going as runoff, which is about 33%, that can be conserved by suitable structures in the watershed. The runoff depth (mm) calculated for different sub basins shows that, basin 6 and 10 are having highest runoff of 194.83 mm and 195.02mm, respectively, followed by basin 9 and basin 7. From the study it was found that, GIS is an efficient tool in calculating the runoff, by preparing the different thematic maps within less time.

Table 4: Basin Wise Weighted Curve Number and Runoff Depth

Basin/Sub Basin	Weighted Curve Number		Runoff Depth, mm
	CNIII	CNII	
1	85.53	72.0	172.09
2	84.80	70.8	171.16
3	85.37	71.7	175.53
4	87.38	75.1	189.81
5	87.21	74.8	188.49
6	87.51	75.3	194.83
7	87.95	76.0	190.39
8	84.51	70.3	174.62
9	87.51	75.3	192.05
10	88.01	76.1	195.02

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